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## CHAPTER 2

# Transport Networks and Impacts on Transport Nodes

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### 2.1 INTRODUCTION

Modern industrial economies have overlapping transportation networks represented principally by road, rail, air, and marine services. Each mode of transport has its inherent strengths and may be used exclusively in some circumstances, but more often two or more modes of transport are involved in the delivery of freight. The locations where goods are transshipped from one mode to another are the nodes of the network. Cities emerge at these transportation nodes to operate as hubs and gateways. Burghardt (1971) defines the difference between transportation hubs and gateways by their geographic characteristics. Hub cities have circular hinterlands where goods are shipped to and from smaller centers. Gateway cities have a one-sided hinterland; the other side is barren in an economic sense. Gateways are located at the edges of their economic regions and serve trade corridors that link its region with another gateway or hub across an “infertile” space. There, goods are transshipped between road, rail, or water for delivery to the final consumer.

As a derived demand, transportation networks expand to serve the needs of shippers and receivers. Larger population centers generate more demand and consequently are the best equipped with infrastructure to accommodate transshipments between transportation modes. A hierarchy of transportation gateways and hubs evolves to accommodate the flow of goods from production to final consumption. The kinds of nodes that form

at particular locations depend on geographical features, political barriers, and established infrastructures. Distance and terrain usually dictate the most favorable routes in which gateways and hubs become established on trade corridors.

This chapter presents the logistical rationale and economics for the formation of transportation gateways, hubs, and corridors. The first section explores the hierarchy of gateways and hubs within the competition for trade among alternative corridors. The growth and success of particular locations are examined with respect to changes in technology and input costs. These forces help to explain the integration of transportation networks and how the fortunes of particular locations for transshipment and industrial activity can wax and wane.

The second section considers trade corridors. Management of congestion, creation of economic rents, and agglomeration benefits are examined with respect to the conflicts that arise within a trade corridor. The third section sets out the economics of transshipment and industrial location. The establishment of job-creating industries is a critical policy goal of modern governments. Where transshipments occur, jobs are located and economies expand. Many incentives are used by governments to attract and retain employment at gateway or hub locations. The economics of transshipment suggests what may be required for success.

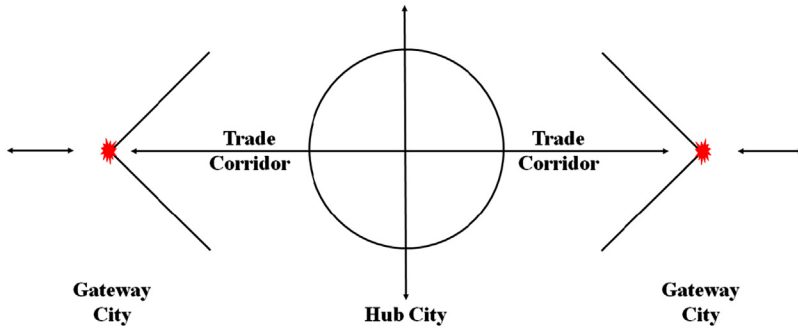
## **2.2 GATEWAY, HUB, AND CORRIDOR CREATION AND GROWTH**

Gateways, hubs, and corridors are integral parts of transportation networks. From ancient harbors such as Alexandria in the Mediterranean Sea, to modern ocean ports such as Rotterdam, the role of cities as entrepôts to a surrounding hinterland depends on the competitiveness of their trade corridor. Transport always seeks the easiest, shortest, and lowest cost corridors, but most trade routes can offer only two of these three needs. Of course, the fortunes of trade routes and their nodes can change over time. The forces of change can be shifting trade patterns, institutional developments, military conflicts, and technological revolutions. As trade routes evolve from the ancient camel caravans serving the Silk Road to China, to jet air freighters and intermodal container ships serving China today, gateways and hubs have traded up and down in economic importance. Cities situated on the leading trade corridors enjoy economic growth, while those located on waning trade corridors enter into relative decline.

A trade corridor can be described as any pathway that facilitates the movement of goods between two or more cities within a broader network of transportation links and nodes that form an economic region. The cities that form trade corridors compete for growth and market share. The largest cities in the hierarchy possess infrastructures and institutions that benefit from economies of scale that smaller cities cannot achieve. The dominant cities can provide more diverse transport connections such as international airports and intermodal rail yards, and higher-level commercial services such as appellate courts, banking, and specialized education. At the very pinnacle of the hierarchy are cities that host national and international insurance, financial services, and entertainment industries.

[Taylor et al. \(2011\)](#) define nine world regions and rank the hierarchy of cities based on their commerce and control. At the national scale, they define cities in terms of how “vertical” or “horizontal” they appear in terms of population size. A vertical distribution is where one “primate city” dominates, such as London, Paris, or Mexico City. A more horizontal distribution can be found in countries such as Germany and China where several important cities vie for influence without any one dominating. Politics and commerce may combine to increase the influence of cities in the hierarchy. Primate cities that are also capitals are more likely to be the dominant air hubs, but not necessarily freight hubs depending on their location. Coastal primate cities such as Tokyo, New York, and Buenos Aires combine sea and air gateways to intercontinental corridors.

The city networks within the world regions are linked together by road, rail, air, and water transport to form competing corridors. Cities on the corridor route can be further classified as distribution hubs and gateways. [Burghardt \(1971\)](#) developed a model of a gateway city that provides a useful framework for considering the entry points of trade corridors. [Fig. 2.1](#) illustrates the hinterlands of hub and gateway cities, and their relation to trade corridors. The hub cities have circular hinterlands that are at the top of their economic hierarchy. The gateway cities have a one-sided hinterland that funnels traffic in and out of its region along a trade corridor. Hub cities rest on one or more major corridors that bisect its circular hinterland. Transportation infrastructure radiates out from the hub city to serve smaller centers within its hinterland. Goods are received from the smaller cities at the hub for consumption and transshipment to other locations, and in reverse, goods received from distant locations are distributed within the hub city’s hinterland. A classic example of a transportation hub is Kansas City, Missouri. This city, which is situated close to the geographic center of the



**Figure 2.1** Conceptual model of hub and gateway cities.

United States, is served by two major interstate highways, four class 1 railways, and all the major airlines.

The hinterlands and economic roles of gateway cities are different than hub cities. Most gateway cities serve only one end of a major corridor that feeds traffic into and out of its region. The one-sided, cone-shaped hinterland is shaped by some geographical transition point or political barrier to trade. Gateway cities lie at the extremes of their geographic regions to transship freight between their “fertile” side and across an “infertile” region on the other side. The fertile side has a well-developed multimodal network of transportation infrastructure. The infertile side is served by long haul transportation services that connect the gateway city to a distant market.

Traffic is funneled through a gateway city because it sits at a strategic location along a land corridor or a sea route where transportation costs can be minimized. Ocean ports are obvious gateway cities, but Burghardt observes that internal gateway cities can emerge where continental features create the right conditions. For example, gateway cities can become located because of mountain ranges, deserts, rivers, and inland seas. Calgary, Alberta, owes its size and location to the strategic Rogers Pass that provides a key transportation corridor through the Rocky Mountains. Calgary emerged as a gateway to distribute goods from British Columbia to the fertile hinterland of the Canadian prairies. Winnipeg was founded as an eastern gateway to this prairie region. With the barren Canadian Shield to its east and north, Winnipeg funneled trade from across eastern prairies over a long corridor that linked to Montreal and Europe. The location of the gateway at Winnipeg was favored because traffic had to be transshipped across the confluence of the Red and Assiniboine rivers. The Winnipeg

gateway to Western Canada became solidified when the Canadian Pacific Railway bridge was built across the river and fixed the route of the trans-Canadian trade corridor.

Whebell (1969) notes that all modern land trade corridor routes became fixed with the construction of the rail lines. Although cars and trucks have greater route flexibility, centers that were already served by rail were subsequently more desirable to connect with highways. In North America, the railway infrastructure is oriented with stronger and more direct east/west corridors than north/south corridors. Even in the case of air travel, which is not tied to fixed infrastructure routes, it is generally easier and faster to fly east/west in North America than to travel north/south. This reflects another source of gateway location—political boundaries.

Political boundaries create gateway opportunities because goods and carriers must stop for documentation, inspection, and travel approval. Sovereign states also impose regulations that limit foreign transport competition (cabotage restrictions) and favor the transfer of goods to domestic transportation systems. Like seaports, sovereign borders within a trading bloc stimulate land settlement patterns and employment to serve international trade. It is unclear whether either Calgary or Winnipeg would have grown into major cities if the United States–Canada border had not limited the reach of American cities further south. No city as large as Minneapolis–St. Paul, Minnesota, exists to its north or west until the Pacific coast. All the gateway functions for the Canadian prairies could have been handled through Minneapolis–St. Paul if the Canada–United States border had not existed.

The impact of technical change provides many historical examples of cities that were once important gateways, only to lose their advantage and become eclipsed by rivals. The history of Chicago and St. Louis is instructive. Located at the confluence of the Mississippi and Missouri rivers, St. Louis had been the gateway to western development for nearly 75 years before Chicago was incorporated as a town (Cronon, 1991). During the age of barges and canals, geography funneled passengers and goods through St. Louis's natural river corridors. In contrast, Chicago had to depend on a seasonal, circuitous route through the Great Lakes and the Erie Canal with its 36 locks. As advances in iron smelting and the telegraph allowed the railways to use longer trains and provide faster, year-round service, they began to outcompete river-barge transport after 1855. Chicago became the foremost railway gateway of North America, while St. Louis became a regional city in its shadow.

The rivalry between Chicago and St. Louis also illustrates another important consideration—strategic corridor partners. The growth and success of Chicago was propelled by its strategic partner New York. St. Louis depended on Philadelphia for its access to goods from the eastern markets, via the Cumberland Gap and the Ohio River. When the rail age emerged, Philadelphia became focused on this coal and steel manufacturing industry and ignored its western trading partner (Cronon, 1991). The New York interests pushed railway investment to link up with Chicago, and New York became the dominant east coast gateway. A similar change in the Montreal–Winnipeg strategic partnership occurred in Canada during the 1970s with the rise of the Separatist movement in Quebec. Business headquarters in Montreal shifted to Toronto and its strategic western partner Calgary. With the decline of Montreal, Winnipeg faded in importance as the regional center of business and distribution in Western Canada (Prentice, 2006).

The role of technical change in the rise and fall of gateways is evident in all modes of transport. Boston was an important seaport during the American Revolution (1763–85), but now because of its shallow draft, it serves mainly fishing and touristic roles. Gander, Newfoundland, was an important international airport until airplanes with greater size and range no longer needed to stop and refuel for transatlantic flights. New technologies on the horizon such as driverless trucks and cargo airships could also favor new gateways at the expense of others. Similarly, technical change can reverse the fortunes of gateway cities. The introduction of double-stacked container trains has revived some of the older railway gateways, such as Winnipeg, that had declined with the rise of long-distance trucking.

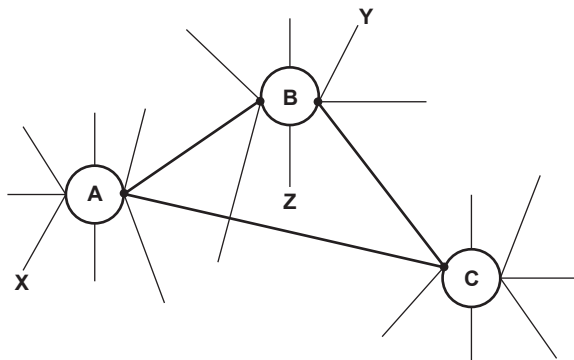
The size of the region and the range of available transportation services define the hierarchy of gateway cities and trade corridors. Ocean ports continuously compete with each other to attract shipping lines. Airport operators try to catch the attention of airline services. Cities work to provide road infrastructure that serves their ports, railway yards, and intermodal facilities.

Once established, gateways and corridors may merge to create networks within which routing and development options multiply. As trade flows grow along any corridor, either infrastructure must adapt to accommodate the increased movement or the market will use alternative gateway–corridor combinations. Within the broader transportation network, this could affect development options, competitive frameworks, and transportation costs.

The difference between cities that operate as gateways or hubs seems intuitively obvious for surface freight shipments because physical geography directs handling and transshipping to the least cost routing. It is not as clear in terms of passenger movements, and especially with the air mode, which cities operate as gateways or hubs. To some degree, every airport is a gateway to the local community it serves, but some airports serve more as transfer points within a larger region, rather than feeding traffic to and from their immediate hinterland. Part of this confusion is related to the concept of the hub-and-spoke transportation network that is illustrated in Fig. 2.2.

The hub-and-spoke configuration is widely used in distribution networks because it offers shippers and carriers efficiency advantages through consolidation and connectivity. Consolidation of passengers or freight to fill vehicles reduces costs and expands the number of origin–destination pairs linked in the network. Connectivity is illustrated by the person living in city X who wishes to travel to city Y. Neither city X nor city Y has sufficient traffic volume to sustain direct flights, but by traveling through hubs A and B, they can access reasonably affordable and convenient air service. The lower cost is obtained through economies of size and the efficient utilization of aircraft. Travelers on the spokes to X and Y fly on smaller airplanes suited to the traffic volume and distance. Between the hubs of A and B, they travel on larger airplanes sized for the longer flights and traffic demand.

Mason (2010) addresses the question of air transport hubs and gateways with a preliminary quantitative analysis of traffic patterns at 23 major airports in North America, Europe, Asia, and the Middle East. He collects data on domestic, continental, and intercontinental flights as well as descriptive



**Figure 2.2** Conceptual model of hub-and-spoke transportation network.



data on city size, location from the coast, number of carriers, proximity of competing airports, and national population and GDP. Based on these data, he compares the activities of the airports and attempts to classify their roles as gateways or hubs.

The results of this quantitative analysis suggest that three categories exist: gateways, hubs, and hybrids that have elements of both. Hub airports have large amounts of connecting passengers and a smaller local origin–destination demand. They can be located anywhere within the region. Examples of hub city airports are Amsterdam, Hong Kong, Dubai, and Singapore. Gateway city airports are characterized by the large share of passengers who are originating or terminating at their airport. Most of the cities located on the spokes of airline networks serve as gateways to their local hinterlands. Hybrid hub–gateway airports have more balance between connecting and terminating passengers. Montreal, Madrid, and Paris could be members of this hybrid group.

Transshipments can be either intramodal (between two carriers of the same mode) or intermodal (between different modes of transport). The intramodal movements are more likely to represent hub-like activity. Examples are the cross-dock transshipment of less-than-truckload trucking, railcar classification yards, container ship feeder services, and airline passenger hub airports. The intermodal transshipments from ocean carriers to railways, from truck to rail at intermodal container terminals, and from airplane to truck transfers occur at the gateways. [Delfmann \(2010\)](#) suggests that this distinction loses relevance because feeder traffic is increasingly found at gateways, and the modal choice in hub-and-spoke networks increasingly involves different modes of transport. An example of the latter could be the courier companies such as FedEx that use airplanes between hubs and trucks as the spokes.

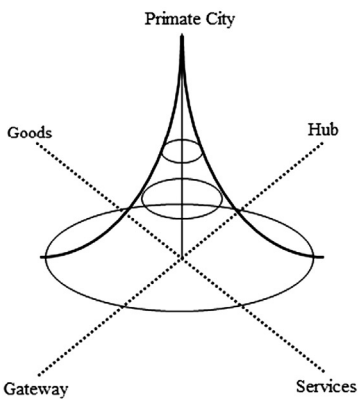
The inclusion of air passenger transport with freight movements highlights the importance that services have in reinforcing gateways and hubs. London and New York sit at the top of the world cities hierarchy defined in terms of culture, knowledge, and financial industries ([Pain, 2010](#)). These cities are no longer the manufacturing leaders of the global economy but their influence extends globally to all the major cities of the world. The world cities' view of the hub and gateway city hierarchy suggests the importance of including services trade with the trade of goods. The primate cities have a balance between goods and services with elements of gateways and hubs. Cities lower in the hierarchy are usually more focused on either goods or services, and can operate more like gateways or hubs.

Fig. 2.3A presents a three-dimensional model of the hierarchy, in which different cities at the same level serve as gateways or hubs with greater proportions of goods and services in their economy. The largest centers generally have a combination of transport modes, but as cities have become more service oriented, a single airport hub may be the most important mode of transport. An example of a city at the bottom of the hierarchy could be an industrial port that is built to serve a single commodity export, such as iron ore.

The model in Fig. 2.3B is a top-down view of the hierarchy, based on the work by Pain (2010), Mason (2010), and Taylor et al. (2011) and the judgment of the author. New York and London are the primate cities sitting at the top of the Anglo-American hierarchy. The cities lower in the hierarchy are smaller in population and have fewer corporate head offices. Boston and San Francisco are gateways with high service focus. Chicago and Vancouver are gateways that are stronger in freight flows. Toronto and Calgary operate more like hub cities for air traffic distribution warehouses and they are the first and second in numbers of head offices. These are hubs with significant service sectors, including tourism. Atlanta and Kansas City are hub cities that serve large circular hinterlands for the movement of goods and people.

Pain (2010) observes two paradoxes in this new role for gateways. First, as cities increase their global connectivity, interurban economic dependencies

(A) Hub and Gateway City Hierarchy: Conceptual Model



(B) North America Hub and Gateway City Hierarchy

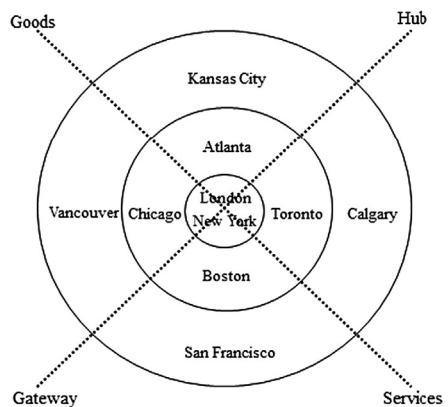


Figure 2.3 Conceptual model of hub and gateway hierarchy with North American example.

are extending and intensifying. A clustering of synergistic intercity linkages becomes more important as these cities become more global. In the case of New York, a cluster of activity encompassing New Jersey and the surrounding megalopolis support the goods movement and feed its industrial activity. The second paradox is that established gateway and corridor roles are becoming detached from, but increasingly dependent on, the physical infrastructures. Notwithstanding Cairncross (1997) views on the death of distance, flexibility and openness to virtual and physical flows are both important to global competitiveness.

## 2.3 DEVELOPMENT OF MARITIME—LAND TRANSPORT NETWORKS

Corridors that serve gateways and hubs vary in length depending on their function and hinterland size. Rodrigue and Hesse (2007) consider four cases. Short-distance corridors exist within gateways and hubs to move goods from port terminals to sorting and marshalling areas. An example is the Alameda rail corridor that serves the ports of Los Angeles/Long Beach, California. This corridor consolidates four rail branch lines into a 15-m wide, 10-m deep trench containing three rail lines. It eliminates 200 at-grade crossing conflicts and reduces the transit time from 2 h to less than 1 h. Containers are carried approximately 32 km through the trench, then another 99 km on connecting rail lines to a cluster of distribution facilities at the Inland Empire. Short-distance corridors can reduce congestion in the port area or compensate for a lack of space. The Inland Empire has ample space to conduct transshipping and sorting. The ports of Los Angeles and Long Beach are now considering on-dock rail loading to reduce the two-thirds of their containers that are still moved through the city by trucks (Tirschwell, 2015).

The second case is hinterland access corridors that expand the market area of the gateway and reduce costs. The Port of Prince Rupert, British Columbia, is hemmed in by mountains. Consequently, container stuffing for shipment through the port has been established 720 km east at Prince George, British Columbia. A similar strategy underlines the development of rail corridors in heavily populated locations such as the east coast of the United States. The Port Authority of New York and New Jersey has established the Port Inland Distribution Network and the Port of Virginia has an associated rail terminal called the Virginia Inland Port to reduce distribution costs.

The third case is long-distance corridors, called landbridges, that are used to connect gateways to internal hubs and gateways. All the major west coast ports in North America have landbridge corridors that converge on Chicago. Of course, a landbridge can also be a transcontinental rail connection from gateway to gateway. Examples are Vancouver to Montreal across Canada and Los Angeles/Long Beach to Houston across the southern United States.

The fourth category of corridors is circum-hemispheric. These corridors usually involve marine shipping lines that connect continental gateways with land corridors. The major container trading routes on the Pacific and Atlantic Oceans are parts of these circum-hemispheric corridors. Two very ambitious circum-hemispheric trade corridors that do not involve marine networks have been proposed. Intercontinental landbridges have been put forward for a rail link between North America and Asia, via a tunnel under the Bering Strait from Alaska to Siberia. A second and more plausible landbridge is a containerized rail link that takes its inspiration from the historic Silk Road between Asia and Europe. Notwithstanding the challenge of coordinating rail movements through a dozen different countries, and the complication of a wider railway track gauge in the former Soviet Union countries, trial shipments on this route have been tested already.

Location on a trade corridor affects the growth of cities and economic opportunity. However, simply being located on a transportation corridor is of no advantage, unless a highway interchange or a railway siding/station is accessible. [Quinet and Vickerman \(2004\)](#) present the theoretical case that the structure of transportation costs and competition leads firms to choose locations at the nodes of transportation networks. The nodes can offer firms the benefits of agglomeration. Each firm locating at the node can gain from its diversity and contribute to the diversity of the city. Larger centers offer opportunities for economies of size, access to labor markets, and easier access to input suppliers. These benefits are self-reinforcing and encourage more growth at the nodes of the network.

As much as the agglomeration effects are a positive externality of transportation corridors, congestion, noise, and air pollution are negative externalities. This leads to a curious paradox. Residents located off the corridors wish they were part of a corridor, while residents living at the nodes of corridors wish the corridor went somewhere else. [Bandyopadhyay and Goetz \(2010\)](#) describe the desire to be on a corridor as “bypass phobia,” the fear of being left out of economic development opportunities. History provides examples in which local business leaders fought to get railway

access. The business leaders at Denver, Colorado, built a spur line to connect to the Union Pacific Railroad at Cheyenne, Wyoming, when the transcontinental was routed there instead. The city of Winnipeg built a railway trestle across the Red River and promised the Canadian Pacific Railway tax-free land to bring the transcontinental route 30 km south. In both cases, the investment paid off because these cities became the largest centers in their jurisdictions. Ironically, in the case of Winnipeg and many other cities, local politicians are now lobbying to have the rail lines routed around the city.

The issues of congestion, noise, and air pollution have been rising as the scale of transportation corridors and gateways increases. The advent of containerization has changed the nature of port cities ([Levinson, 2006](#)). The large populations of rowdy dock workers and “drunken” sailors have been replaced by relatively clean and quiet container terminals. Cities that were once considered rough and gritty, such as Vancouver, are now hailed as some of the most desirable residences in the world. This does of course create a conflict between the local populace who want to build condos on the shoreline and the port authorities and freight terminals that need this space to transship goods. Also the volume of container drayage movements to and from these port terminals adds to traffic congestion and city streets may be blocked by container trains. Residents who are not directly employed in transport at the nodes of the network can easily overlook the benefits and resent the external costs of moving goods that are derived from somewhere else and shipped to another destination outside the gateway.

Much can be learned about gateways and corridors from the history of the 7000-km long trade route, known as the Silk Road. [Frankopan \(2015\)](#) and [Hansen \(2012\)](#) provide in-depth analyses of the origins and operations of this 1500-year-old trade corridor. As these authors note, the Silk Road moniker was coined in the 19th century based on the observation that silk was a key trade commodity. Like all trade corridors, goods moved in both directions. In addition to silk, furs, jade, ceramics, spices, paper, iron, and bronze were shipped westward from China. The returning eastbound cargoes were gold, gems, ivory, glass, textiles, and perfume. Traffic was limited to valuable luxury goods because the cost of transportation was high and warring tribes made travel dangerous.

Security and political relations are vital to trade. The Silk Road had two periods of great activity, interspersed with breaks. From 50 BC to approximately AD 250, the overland trade route connected the more advanced Han Chinese culture with the Roman Empire in Europe. The

Han Dynasty provided security in the east and the Romans in the west. There is no evidence of direct contact, as represented by Roman coins, until the Byzantine era (Frankopan, 2015; Hansen, 2012). With the decline of the Roman and Chinese empires after AD 400, the network became unsafe. The modern equivalent is the threat to trade flow posed by terrorism. A paramount concern is the risk of a nuclear device in a container, dubbed “the modern Trojan Horse.” Trading freely through open borders is an important benefit of transportation security (Prentice, 2008). A three-level approach of information, collaboration, and equipment to detect any possible threat preoccupies the government of the United States (Vicinanze, 2015). Should this nightmare scenario ever occur, the affected trade corridor would cease to operate for an indeterminate period.

More than goods are transmitted along trade corridors. Culture, religion, domesticated animals, crops, and inventions were exchanged between west and east. It was also the avenue to the spread of diseases such as measles, bubonic plague, and small pox, which devastated populations. The most infamous dissemination of disease is the Plague of Justinian that arrived in Constantinople in AD 542 and persisted for 225 years. It devastated populations at both ends of the Silk Road, killing between a quarter and half the European population and disrupting all trade. Modern health concerns, such as severe acute respiratory syndrome, Ebola, and Sika virus, led almost immediately to bans on travel and cutting off trade relations. When the threat goes away, trade resumes. With the rise of the Tang and Song dynasties, the Silk Road became vibrant again for a second period from AD 700 to 1200. Whether the subsequent break in the trade corridor is coincidental with the second incidence of the “Black Death” in the mid-1200s, or its result, requires further research.

Trade corridors are comprised of intermodal supply chains. The Silk Road operated like a relay system in which goods were passed from trader to trader at distances less than 500 km, rather than as an integrated supply chain. Camels, horses, and donkey carts were used. Each camel could carry between 400 and 500 lb, but traders enjoyed economies of size with armed escorts. Some caravans exceeded 1000 camels. In modern times, trade corridors have embraced economies of size with larger container ships and longer double-stacked container trains.

The tourist map of the Silk Road illustrates a highly stylized impression of the trade route. The map illustrates the extremely rich cities that were located at the oases. Like cities located on modern trade corridors these

centers benefited economically from the passage of traffic. Where the map is misleading is in its impression that a single, well-developed route existed. Like modern trade corridors and gateways, the Silk Road was comprised of several parallel competing routes that took advantage of different transportation gateways. No well-defined roads existed between Europe, India, and China, only trails that led to strategic oases and mountain passes. The map also indicates a sailing vessel in the Arabian Sea. This alternative sea route was certainly known at the time, but pirates made it as dangerous then as it is in modern times. As mentioned earlier, lack of security discourages trade.

New trade corridors can be spurred by political, environmental, and economic forces. Sea routes through the Arabian Sea were fraught with pirates, while overland communications with China were cut off by the Ming Dynasty (1368–1640). This encouraged the search for a different sea route to China. The pioneering of marine technology by the Portuguese led to a better sea route around the Cape of Good Hope that made the Silk Road obsolete for continental trade and ultimately led to the discovery of the Western Hemisphere.

Environmental forces can disrupt trade and open up new trade corridors. The oases on the Silk Road became unreliable during the Late Antique Little Ice Age that lasted from AD 536 to 660 (Büntgen et al., 2016). Today, climate change may disrupt established ports and open up new trade corridors. If concerns about the impact of the rising of ocean levels are realized, the infrastructure of most port facilities will be subject to damage during storm surges. The warming ocean is also opening up new trade corridors in the Arctic Ocean. This could diminish activity through the Panama Canal, and possibly the Suez Canal. Like the oases, some ports could be abandoned with great disruptions of populations.

## **2.4 THE ECONOMICS OF TRANSSHIPMENT AND INDUSTRIAL LOCATION**

Coastal gateway cities are among the largest population centers worldwide. They became established and prospered by offering a collection of value-adding activities that serve multiple supply chains. Value-added services create place utility, time utility, and form utility. The economy of a gateway city can be expanded by transportation terminals and drayage services (place utility), by logistics and warehousing services (time utility), and by the operations of processing or manufacturing industries (form

utility). Freight terminals have to be physically located at the gateway because their role is to transship goods between modes of transport. Other economic activities can be located elsewhere, but traditionally the gateway cities have been the most favorable location. As noted earlier, changes in technology and communications can alter the competitive advantage of location.

Until the advent of containerization, all shipping was either bulk or breakbulk. Bulk shipping is the movement of loose cargoes, such as grain, fertilizers, coal, and minerals, that are loaded with mechanical handling equipment, such as “clam-shell” cranes and conveyors, into the ship’s holds. Breakbulk cargo is packaged in smaller containers such as boxes, drums, and crates, and loaded with cranes and nets. The introduction of ISO container shipping has led to a steady decline in breakbulk cargoes. Breakbulk is still used for out-of-gauge cargo, which is essentially anything that will not fit in a standard ISO container, but most packaged goods are containerized.

Levinson (2006) chronicles the impacts of containerization since its inception in 1957. Prior to containerization, approximately half the cost of shipping breakbulk goods across the Atlantic Ocean occurred at the port. All outbound goods were unloaded at the port, placed on pallets, and moved into a transit shed to await the ship’s arrival. Once the ship docked, the goods were lifted by cranes off the dock and down into the ship’s hold. There, the pallets were unloaded into the various decks. Levinson illustrates the process for one ship (the SS *Warrior*) that carried 5015 long tons from New York to Germany in 1954. The cargo list contained 194,582 individual pieces, mainly food and general freight, that were packed in cases, cartons, bags, bundles, drums, barrels, reels, crates, and just about every other conceivable packaging form. These export goods arrived at the port in 1156 separate shipments from 151 different cities in the United States. The ship took 6 days to load (single 8-h shifts) and 4 days (around the clock) to unload at Germany. Compared to 10.5 days to cross the Atlantic, this ship spent almost as much time docked at the ports. Today, container ships carrying 10 times the volume can be loaded and unloaded in a single day. The lower cost of containerized ocean transport has allowed manufacturers to create global supply chains.

Containerization has greatly increased the volume of goods moving through the ports, while advances in communication technology sped up inventory turnover and reduced the cost of inventories in transit. The shift from breakbulk to container ships eliminated thousands of jobs on the docks, but the reduction of transportation costs created thousands more.



Workers are employed driving drayage trucks to move the containers to and from the ports. More workers are employed unloading goods into distribution warehouses and loading intermodal rail containers and trucks for inland distribution. Yet more jobs have been created in a variety of supply chain management positions to deal with the information processing and inspection functions of trade. Containerization greatly reduced the number of longshoremen employed loading and unloading ships, but total port-related employment is much larger today.

Processing and manufacturing industries are traditional sources of employment at the gateways because firms can benefit from proximity to the transshipment point. This is especially true if the goods being transshipped are costly to handle or perishable. Processing can also be advantageous at a gateway if several raw materials are being sourced from different locations. The creation of the steel industry at Tokyo is an example. Metallurgical coal, iron ore, and limestone can be transported by sea and combined with domestic scrap metal to produce quality steel. Weight or volume-reducing processes can also take advantage of a gateway location. Ocean transport is less costly than land transport, so any reduction in weight or volume lowers total distribution cost.

An economic model that illustrates the advantage of industrial location at a gateway city is presented in [Fig. 2.4](#).

The assumptions of this model are that the resource can be processed into a consumer good at its origin in the factor market, at the transshipment point  $d^*$ , or at the consumer market. The costs of transport are summed vertically to obtain the total costs. At the consumer market, the distribution costs are assumed to be zero for finished goods, so the transportation costs are just for the procurement of the raw materials. Similarly, at the resource market, only the distribution costs to ship the finished goods to the consumer market are considered. If the processing occurs at the transshipment point, the procurement costs of the raw material by sea and the distribution costs of the finished goods by land are summed to obtain the total costs. Note that the procurement costs of the raw materials and distribution costs of the finished goods shift vertically at the transshipment point  $d^*$ . This reflects the transshipment costs of unloading and reloading different vehicles. Given the model presented in [Fig. 2.4](#), a processing location at the transshipment point is favored because it has the lowest total costs.

Containerization has also changed the economics of industrial location because the costs of transshipping have decreased substantially.

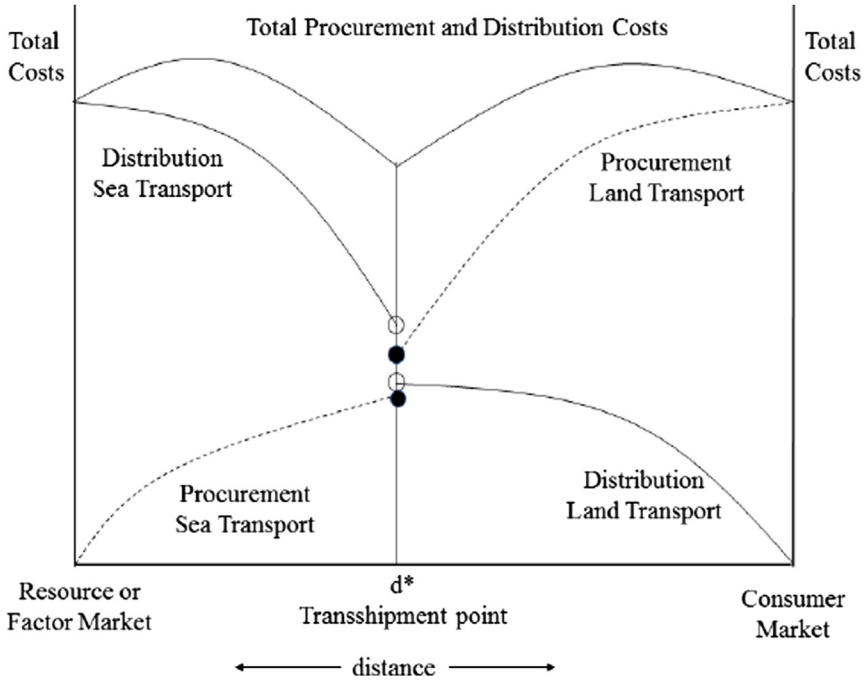


Figure 2.4 Industrial location at a gateway.

Rodrigue (2010) notes that the efficiency of the corridor serving a gateway has a significant impact on industrial location:

*In China, Special Economic Zones (SEZ) are an implicit acknowledgement that the accessibility of the hinterland is weak so that activities must be located as close as possible to the gateways. Empirical evidence has underlined that it costs more to move a container from inland China to a coastal port than across the Pacific and across North America. Reflecting these heavy constraints, most of the development in China has taken place along the coast; a process linked with the export-oriented development strategies.*

It is always the total costs that matter. The high cost of internal transportation in China caused a large-scale migration of people to the jobs on the coast. In contrast, countries such as the United States with well-established corridors move the goods and establish the jobs where the people are located. Of course, this was not always the case. The largest cities in most of the industrially advanced countries are located on the coast because when they were being founded, their internal corridors were inefficient and expensive, too, just like China and most developing economies are today.

Bulk handling has received less attention in examinations of the gateway activities because of the dramatic rise of containerization. It is also true that bulk handling has fewer linkages within the gateway of exporters and consequently less employment impact. Nevertheless, the efficiency of bulk handling is critical to the competitiveness of countries that depend on natural resource exports. The import gateways for commodities handled in bulk are more likely to be the location for processing because these goods are usually heavy and low in value. Grain is a good example of a bulk commodity that fits this description. The port facilities for exporting grain comprise large storage terminals and rail sidings for receiving and transshipping to ocean-going ships. The port facilities of the importing countries often feature flour mills and oil processing plants. In any case, locations that engage in bulk handling are almost always gateways rather than hubs.

Competition between ports is evolving into competition between supply chains. Containerization has grown rapidly by shifting breakbulk shipments into containers, but it has also started to convert commodities that traditionally moved in bulk into the container supply chain. In part this has occurred because of the great imbalance of container shipping on the Pacific Ocean. The increasing exports of Asian manufactured goods, since the beginning of the 21st century, far exceeds its imports. Over half of all west-bound containers on the Pacific return empty, and are available at very low backhaul rates. This has also been accompanied by rising incomes and increasing demand for grain in Asia. Grain shippers have realized this opportunity. Approximately 15% of total grain exports from North America now move in containers to Asia outside the established bulk grain supply chain (Prentice and Hemmes, 2015). In the United States, grain is being loaded into containers at Chicago and Kansas City that favors shipment through Los Angeles/Long Beach, which have not been traditional export ports for grain.

## 2.5 SUMMARY

The formation of transportation networks and the growth of cities where transport nodes occur are simultaneously determined. Economic opportunity attracts population growth and support investment in transportation infrastructure to facilitate the trade of goods and the movement of people. The initial choice of location for land settlement typically depends on some natural geographical feature or political boundary that favors the least cost trading route. However, many factors can influence the competitiveness of

individual cities and trade corridors. The invention of new modes of transport and economies of size can alter the advantage of particular gateways and hubs. Similarly, many other influences from security issues to climate change can reorder the hierarchy of cities and trade routes.

The traditional view of transport networks and nodes focused exclusively on the movement of goods. In the postmodern world, the trade of services has become increasingly important. It has also changed the attitudes of citizens living at the gateways or hubs. Service industries see the benefits stimulated by the trade of goods, while residents experience the negative externalities of congestion and noise that they create. The importance of particular gateways and hubs may rise or fall as the world economy evolves. What is more certain is the importance of competitive trade corridors. Global supply chains depend on efficient transportation networks and economic growth is likely to occur at the nodes of these networks.

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